section 5

CD V-700-6B



specifications:

- Ranges: 0-0.5, 0-5, 0-50 mr/hr
- Sensing Element: Geiger Tube
- Accuracy: ±15% of true dose rate from cobalt 60 or cesium 137 gamma radiation
- Batteries: Two 1-1/2 volt NEDA 13
- Dimensions: approx. 9" long x 4-1/2" wide x 6-1/2" high including handle
- Weight: approx. 4 lbs. including batteries

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GENERAL DESCRIPTION

Introduction

The Lionel CD V-700 model 6B is a portable geiger counter instrument designed for the detection of low levels of beta and gamma radiation. The geiger tube is mounted in a probe on the end of a thirty-six inch cable. The entire instrument and its accessories include a circuit box, a probe, a headphone, and a carrying strap. A radioactive sample is mounted on the side of the case for checking the operation of the instrument.

Sensing Indicators and Control

A meter with a scale reading in milliroentgens per hour (mR/hr) is used for visual indication and a headphone is used for aural monitoring. The meter is ruggedized and sealed in a plastic case to meet the instrument requirements for water-tightness, shock and vibration resistance.

The meter is controlled by the range selector switch labeled "OFF, X100, X10, and X1". The range switch changes only the meter ranges. It does not affect the number of "clicks" in the headphone.

Readings

Table 5-1 lists switch positions and the corresponding meter readings.

Figure 5-1 shows the meter face. Readings should not be taken with the pointer indicating in the lower 10% of the scale. Turn to the next most sensitive range until the pointer indicates in the upper 90% of the scale.

Switch Position	Counts/Minute	mR/hr
X1	0-300	0-0.5
X10	0-3000	0-5.0
X100	0-30,000	0-50

Table 5-1. Switch Positions vs Meter Readings

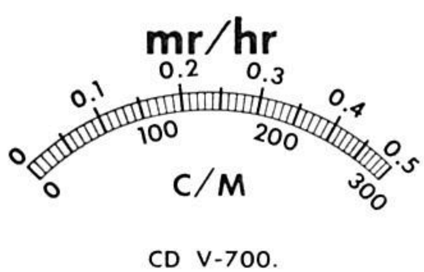


Figure 5-1. Meter Face

Initial Check

With the batteries installed, turn the range switch to the X10 position. Close the beta window of the probe. After thirty seconds the circuit should be stabilized and the meter should read zero.

Open the beta window on the probe and place the open window on the center of the OPERATIONAL CHECK SOURCE on the side of the instrument. The meter reading should average between 1.5 and 2.5 mR/hr.

Background Count

Normal background radioactivity is about 0.01 to 0.02 mR/hr or about 20 counts per minute. Counts are randomly spaced and several seconds may elapse before any activity registers on either the meter or the headphone. Accurate measurements of background and other low level radiation can be

made by counting the headphone "clicks" against a watch that has a second hand. Note the number of counts occurring in a time period of 5 minutes. Divide the number of counts by 5 and the background count is expressed in terms of counts per minute. More accurate measurements may be made by extending the time period.

Batteries

The CD V-700-6B is powered by two 1-1/2 volt "D" size flashlight batteries. The batteries will operate the instrument continuously for over 100 hours and intermittently for over 175 hours. Refer to the battery substitution tables for acceptable types and makes of batteries.

Installation

Open the instrument by lifting the pull catch at each end of the case and separating the two halves to expose the battery compartment and the retaining clips. Remove the clips by squeezing the ends and lifting. Insert fresh batteries according to the polarity marked on the inside of the battery compartment. (See figure 5-2) The battery compartment will not accept the batteries with the polarity reversed. Install the battery clips and close the case by aligning the two halves and closing the pull catches.

Replacement

If the instrument fails to operate, check the batteries before attempting to make any repairs or adjustments. A battery tester may be used or the batteries may be checked under load with a voltmeter while installed in the instrument. If a weak cell is indicated, it is recommended that both be replaced at one time.

Electronic Circuitry

Power Supply

The power supply consists of a blocking oscillator circuit in which pulses are generated by a transistor, V1, alernately cut-off and saturated. The

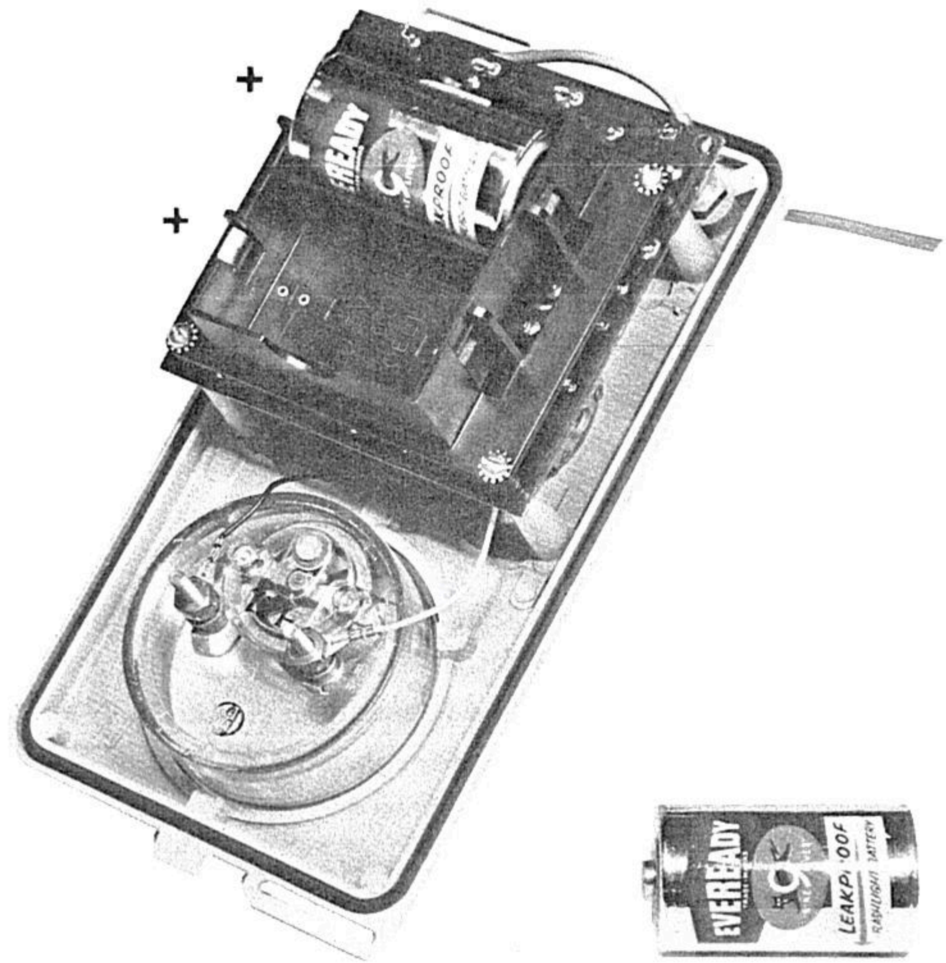


Figure 5-2. Battery Installation

transformer windings between the base and collector are so phased that when the collector current starts to flow, the voltage at the base goes in the negative direction. By virtue of the base going negative, the collector current will increase still further causing the base to go more negative. The collector current increases until the transistor saturates, at which point the collector cannot supply the current demanded by the signal at the base. At this point, since there is no rate of change of current in the transformer, there is no signal induced in the base winding. Therefore, the emitter current decreases, decreasing the collector current. The signal then induced at the base of the

transistor is such as to make this action cumulative until the transistor cuts off. The collector current stops abruptly, causing a large rate of change of current in the transformer. This makes the base go negative, which in turn starts the collector current flowing and the cycle repeats.

The step-up turns ratio between the collector winding and the secondary winding produces a high voltage pulse, which is then rectified by the selenium rectifier CR1.

The D.C. output voltage developed across capacitor C2 is regulated by the corona discharge voltage regulator tube, V4. This regulation stabilizes the voltage supply to the geiger tube for battery voltages within the normal operating range. The high voltage is regulated at approximately 920 volts ±20 volts in most units.

The negative voltage pulses at the collector of the transistor are rectified by CR2. Capacitor C3 is used as a filter and the resultant negative voltage is used as a supply for the audio and metering circuits. During each pulse the voltage regulator tube conducts heavily and saturates the core of the transformer. This saturation clips the pulse at the collector and regulates the voltage across capacitor C3.

Pulse Shaping and Metering Circuit

The pulse shaping and metering circuit is basically two transistors, a rectifier and a meter. Transistors V2 and V3 form a collector coupled, monostable multivibrator. A negative pulse from the geiger tube is coupled to the base of V2, the normal cut-off transistor. This pulse causes V2 to conduct, and a positive pulse is developed on its collector. The positive pulse is coupled to the base of V3 through the timing capacitor and cuts off transistor V3. The resulting negative pulse on the collector of V3 is coupled to the base of V2 by the resistive voltage divider consisting of R12 and R5. This condition with V2 conducting and V3 cut off will continue for a period determined by resistor R14 and the time capacitor selected by the range switch. The voltage pulse at the collector of V2 is rectified by silicon rectifier CR5 and fed to the meter, M, through current limiting resistors R9 or R10. The voltage pulses at the meter are integrated by capacitor C8. The average voltage indicated on

the meter is proportional to the frequency of the input pulses. Resistor R13 calibrates the instrument by shunting some of the current around the meter.

Audio Circuit

Aural monitoring is achieved by diode coupling and a headphone. Each pulse counted by the pulse shaping circuit develops a positive pulse at the collector of V2. This pulse is coupled to the headphone jack by CR4 and differentiated by capacitor C5. When the headphone is connected at the jack, a pulse of approximately 12 volts is developed across the headphone resulting in a clear audible click.

SERVICING

Precautions

High Voltage Power Supply

The high voltage power supply of the instrument operates in excess of 900 volts. The shock is uncomfortable rather than dangerous but should be avoided. The high voltage components should not be touched even when the instrument is turned off until the high voltage capacitor has been discharged. This capacitor is to be discharged by shorting the voltage regulator tube. Do not short the geiger tube leads since this causes component failure in some models.

Geiger Tube

Care must be exercised not to dent the geiger tube. Dents in the tube may cause arcing at voltages lower than the operating voltages and the tube will be useless. Dropping the tube may cause leakage of the gas mixture.

Semi-Conductor Components
(Diodes and Transistors)

The diodes and transistors used in the instrument may be damaged by prolonged heating during soldering. When replacing any of these components, the soldering operation should be done quickly. Hold the lead between the com-

ponent and the joint with a heat sink to decrease the amount of heat transmitted to the component. Techniques are described in section 1 of this Manual. The leads of the high voltage rectifier may break if subjected to strain when removing the component from the circuit board. Use a soldering aid to lift the leads.

Disassembly Instructions

1. Remove the instrument from the case bottom and remove the batteries.
2. Remove the four screws with lockwashers from the battery box.
3. Remove the selector knob from the front panel by loosening both set screws.
4. Disconnect the meter by removing the two nuts holding the connecting lugs.
5. Remove the circuit board from the case top by pressing on the selector shaft. Remove the board slowly since the geiger tube lead and the headphone jack lead are still connected. The circuit board is now ready for trouble shooting. The meter may be conveniently reconnected by the use of test leads.
6. Reassembly is the reverse of the above process. However, it is necessary to make sure the geiger tube shield connecting lug is connected to the circuit board during reassembly. The lug connection fits between the circuit board and the case top leg. An eyelet on the circuit board designates this corner of the circuit board.

Preventive Maintenance

It is recommended that preventive maintenance be carried out once a month when the instrument is in use and once every six months when the instrument is in storage.

1. Remove the batteries, clean the battery contacts and battery terminals if necessary, and remove any corrosion present.
2. Replace all batteries which do not exceed minimum voltages.
3. Perform the Initial Check as described on page 5-2.
4. If the instrument is to be shipped or stored, remove the batteries and

set the selector switch to one of the sensing ranges. This will shunt the meter and minimize damage from the movement of the pointer during shipment or storage.

Do not use solvents on plastic parts. Clean with soap and water. If the battery has leaked, remove the case bottom and wash it with warm soapy water being careful not to soak off the circuit diagram or the CD decal. The battery spillage will be loosened in a short while and can be rinsed out.

Repairs

Replacing the Geiger Tube

1. Grasp the end caps of the probe and twist in a counterclockwise direction to unscrew the tube housing from the socket housing.
2. Insert the new geiger tube into the socket pressing the tube into the socket and against the rubber gasket. Do not handle the thin beta window.
3. Place the tube housing over the geiger tube.
4. Engage the threads of the tube housing and socket housing with a steady pressure against the shock mounting spring and screw together in a clockwise direction. Overtightening may interfere with the operation of the beta shield.

Replacing the Voltage Regulator Tube

The VR tube is held to the circuit board with a standard fuse clip. To remove the tube, unsolder the leads and press on the top of the tube to lift the leads. The new tube should be installed with the cathode connected to ground and the anode (red dot) connected to point H. (See figure 5-4) Position the leads so that no strain is exerted on the metal-to-glass seals. Figure 5-3 shows a properly installed voltage regulator tube.



Figure 5-3 VR Tube Placement

Replacing the Geiger Probe

1. Remove the battery compartment and unsolder the probe lead from the circuit board.
2. Remove the seal nut with an adjustable wrench.
3. Untie the knot, remove the solder lug, and pull the cable through the hole in the case top.
4. Prepare the new cable according to instructions in section 1 of this Manual.
5. Twist the center conductor and shield together to allow the wire to be inserted through the case top. Pull on the end of the cable with pliers until a sufficient amount extends through the case top.
6. Replace the seal nut and washers on the new cable and tighten the seal nut using moderate pressure. Excessive tightening can damage the cable. Tie a knot in the cable near the seal nut.
7. Connect the cable to the circuit board and replace the battery compartment. The ground lead is soldered to a lug under the nearest case top leg.

Replacing the Switch

The switch assembly is held rigidly to the circuit board and is difficult to remove. For best results, follow this procedure carefully:

1. Disassemble the instrument through step 5 of the Disassembly Instructions.
2. Heat each switch terminal on the circuit board, one at a time, and press sideways on the switch shaft. This will tend to lift the terminals from the circuit board. Prying carefully with a soldering aid may aid this process. Repeat several times, pushing <u>away</u> from the solder joint each time, until the switch is free.
3. Open the holes on the circuit board with a soldering pencil and soldering aid to allow the switch terminals to be inserted.
4. Insert the new switch and solder each terminal using a minimum amount of heat. It is not necessary to twist the terminals before soldering them. Be sure the switch is seated properly so that the shaft will fit through the hole in the case top.

Trouble Shooting

The information in this section is presented as an aid to the service technician in determining the causes of specific instrument faults. The Trouble Shooting Guide lists the most probable causes of instrument failure together with suggestions for corrective action. This should be consulted and followed after the following preliminary steps have been taken:

1. Disassemble the instrument through step 2 of the Disassembly Instructions.
2. Check all batteries. Make sure they provide sufficient voltage for proper operation of the instrument.
3. Check the printed circuit board for broken foil, cold solder joints, or solder bridges.
4. Check for broken components.

Table 5-2, Test Point Chart, and figure 5-4, Location of Test Points, eliminate the need for circuit tracing when making voltage and resistance measurements. The Test Points are referred to in the NOTES column of the Trouble Shooting Guide, and are also found on the schematic circuit diagram.

TROUBLE SHOOTING GUIDE

SYMPTOM		PROBABLE CAUSE	CORRECTIVE ACTION	NOTES
Meter	Headphone			
Dead	Dead	Batteries low or making poor contact	Check batteries and contacts	
		Geiger tube defective or not compatible with instrument's high voltage	Replace geiger tube or correct instrument's high voltage	Check starting voltage of tube. This must be lower than voltage at point H
		Probe shield shorting to high voltage power supply	Dress leads	Voltage at H=0. V2 may be damaged
		Geiger probe defective	Repair or replace geiger probe	Check V2 for damage after repairing probe
		CR1 defective	Replace CR1	Voltage at H low
		CR2 shorted	Replace CR2	Voltage at A=voltage at N
		CR2 open	Replace CR2	Voltage at A, F low

SYMPTOM		PROBABLE CAUSE	CORRECTIVE ACTION	NOTES
Meter	Headphone			
Dead (cont'd)	Dead (cont'd)	V1 defective	Replace V1	Check voltages at A, F, H. Check V1 for beta and shorts. Check T1 before replacing V1
		V2 defective	Replace V2	Check V2 for beta and shorts. Check probe and C4 for shorts before replacing V2
		T1 defective	Repair or replace T1	Check resistances at K - ▲, N - L, J - L
		C1 open	Replace C1	Voltage at H low
		C1 shorted	Replace C1	Voltage at A, F, H low
		C2 shorted	Replace C2	Voltage at H low
		C3 shorted	Replace C3	Voltage at A=voltage at L
		C4 open	Replace C4	V4 Voltages normal. Check by tapping with screwdriver at probe pin 1 and at point G
		C4 shorted	Replace C4	Voltage at H low. V2 may be damaged

Dead	Weak	V3 defective	Replace V3	Check V3 for shorts
Dead	Normal	Meter defective	Repair or replace meter	
		Calibration control turned fully counter-clockwise	Recalibrate	
		CR 5 open	Replace CR5	
		C8 shorted	Replace C8	
Dead (X100 only)	Normal	C6 open	Replace C6	
		Open contact on S1B	Repair switch	Check continuity at F - Q
Dead (X10, X1 only)	Normal	C7 open	Replace C7	
		Open contact on S1B	Repair switch	Check continuity at F - P
Dead (X100, X10 only)	Normal	Open contact on S1C	Repair switch	Check continuity at D - F
Dead (X1 only)	Normal	Open contact on S1C	Repair switch	Check continuity at E - F
Normal	Dead	Poor connection in headphone plug or jack	Repair connection	
		Headphone defective	Repair or replace headphone	

SYMPTOM		PROBABLE CAUSE	CORRECTIVE ACTION	NOTES
Meter	Headphone			
Normal (cont'd)	Dead (cont'd)	CR3 defective	Replace CR3	
		CR4 defective	Replace CR4	Test by shorting
		C5 defective	Replace C5	
Upscale	Dead	V2 defective	Replace V2	Check voltages at G and F
		V3 defective	Replace V3	Check V3 for beta and shorts
Upscale (X100 only)	Dead (X100 only)	C6 shorted	Replace C6	
Upscale (X10, X1 only)	Dead (X10, X1 only)	C7 shorted	Replace C7	
Upscale	Squeal or Buzz	C1 open	Replace C1	
		C2 open	Replace C2	Check voltage at H. Symptoms may cease when voltmeter is connected
		C3 open	Replace C3	Voltage at A, F low
		T1 defective	Replace T1	
Upscale	Hiss or Click	Probe shield shorted to high voltage power supply	Dress leads	Voltages at H low or intermittent. V2 may be damaged

		Geiger probe defective	Repair or replace geiger probe	Voltage at H low or intermittent. V2 may be damaged
		Geiger tube defective	Replace geiger tube	
		V4 defective or not making contact to circuit board	Replace or resolder V4	Voltage at H high
		T1 defective	Repair or replace T1	Voltage at H low or intermittent
Erratic	Normal	C8 open	Replace C8	
		Meter defective	Repair or replace meter	
High or Low	Normal	R13 not adjusted properly	Recalibrate	
		Geiger tube defective or not compatible with instrument's high voltage	Replace geiger tube or correct instrument's high voltage	
		Meter defective	Replace meter	
		CR5 defective	Replace CR5	
		CR1 defective	Replace CR1	Voltage at H low
		V2 or V3 beta low	Replace with transistor having proper gain	
		V5 defective	Replace V5	Check voltage at H

SYMPTOM		PROBABLE CAUSE	CORRECTIVE ACTION	NOTES
Meter	Headphone			
High or Low (cont'd)	Normal (cont'd)	C2 defective	Replace C2	
		C8 defective	Replace C8	
		Open contact on S1C	Repair switch	Check continuity at F - D, F - E

RESISTANCE CHART

Remove batteries before checking resistances. All values ±20%.

Component	Points	Range Switch Position	Resistance (ohms)	
S1A	M - ▲	All except OFF	0	
S1B	F - Q F - P	X100 X10, X1	0 0	
S1C	F - D F - E	X100, X10 X1	0 0	
T1	K - ▲ N - L J - L	Any Any Any	5800 4.4 2.7	5000 8 4.8

VOLTAGE CHART

Voltages negative with respect to point ▲. Use a 20,000 ohms per volt meter. All values ± 20% except where noted.

Point	Voltage	Voltmeter Range
H	-920	*
A	15	25
F	15	25
C	3.2	10
B	3.2	10
L	3.0	10
G	**2.7	3
N	***2.0	3

*Use a high impedance voltmeter. See Appendix B.
**May be slightly lower on some units.
***May be slightly higher on some units.

Table 5-2. Test Point Chart

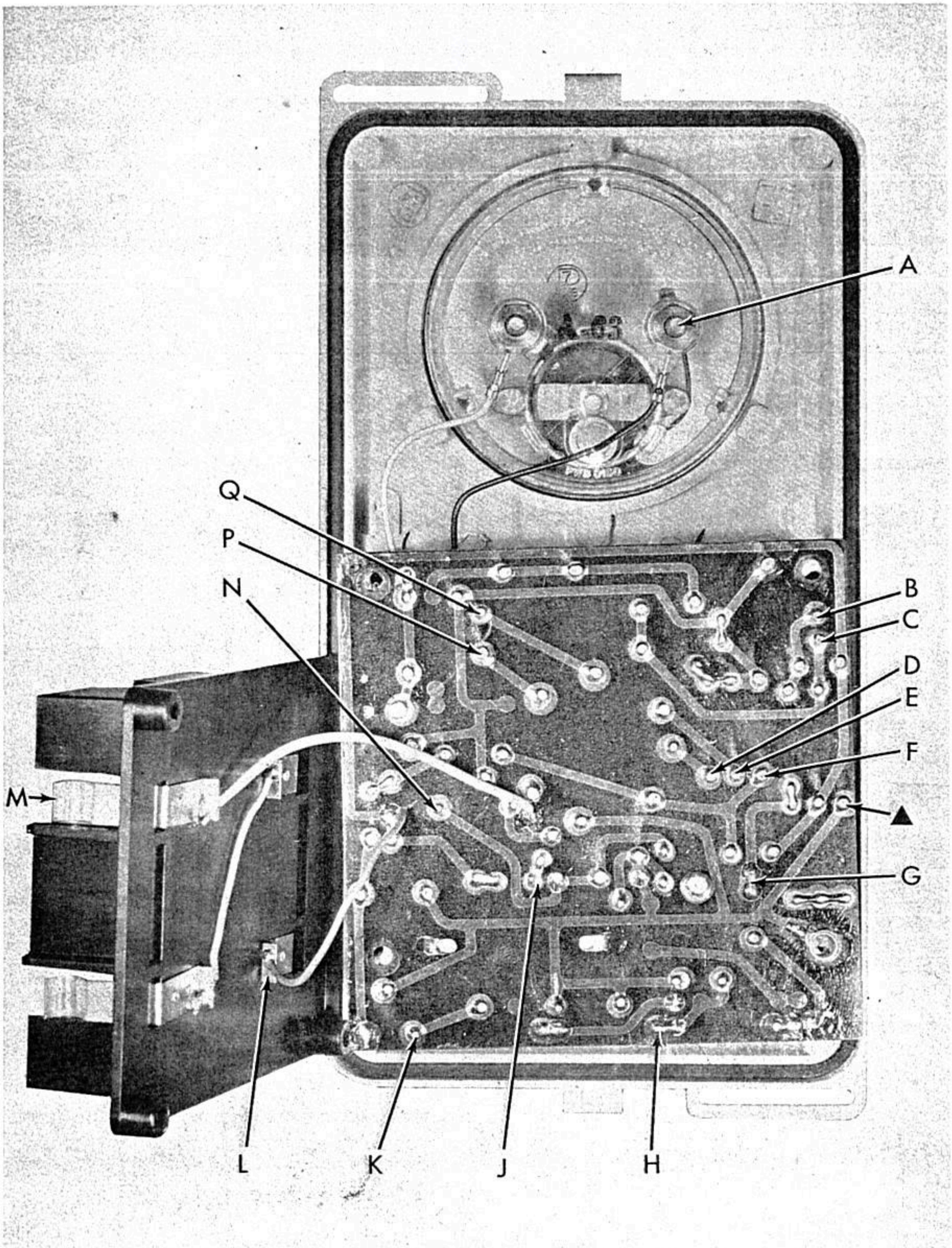
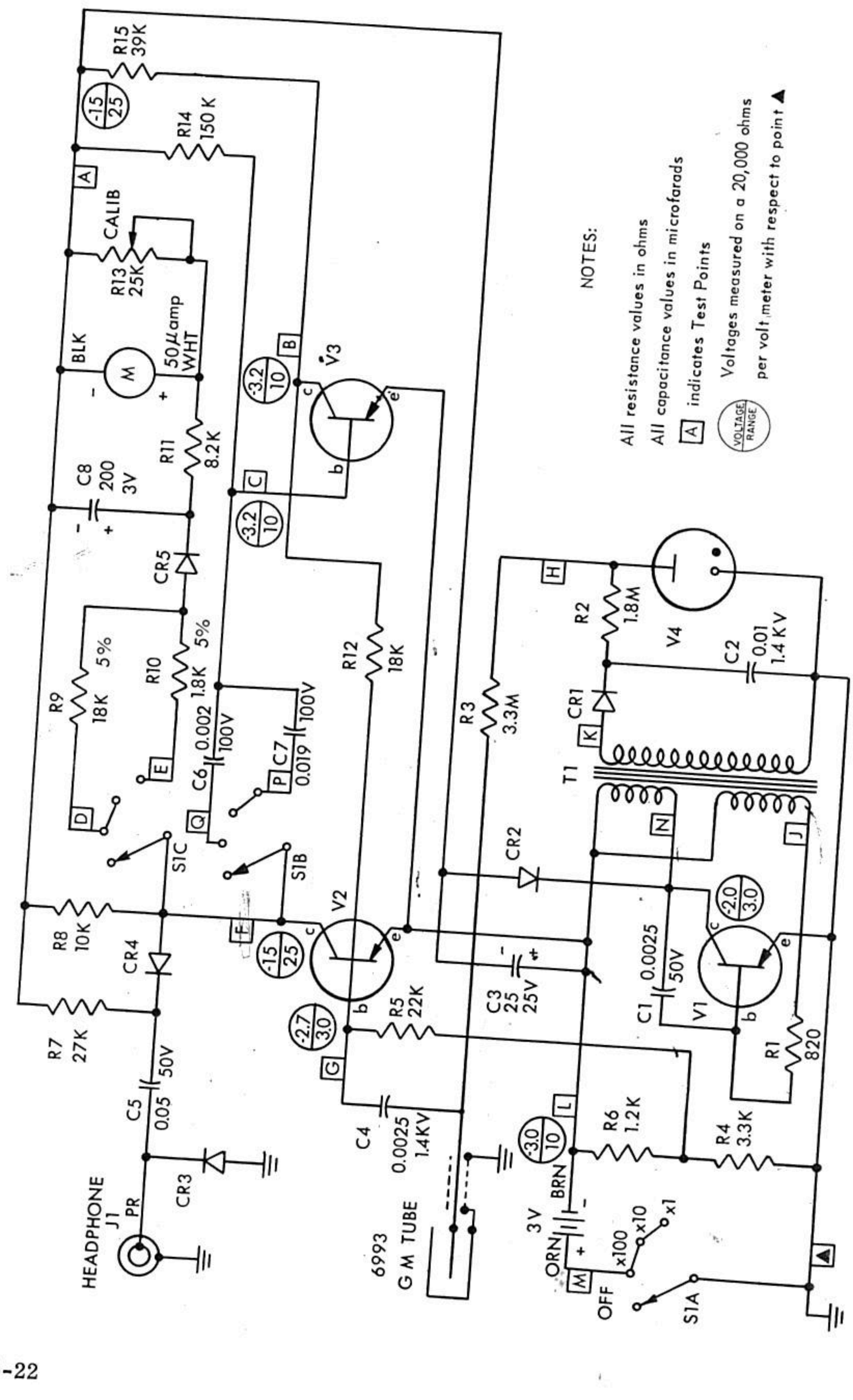


Figure 5-4. Location of Test Points



NOTES:

All resistance values in ohms

All capacitance values in microfarads

[A] indicates Test Points

(VOLTAGE / RANGE) Voltages measured on a 20,000 ohms per volt meter with respect to point ▲

Figure 5-5. Schematic Circuit Diagram

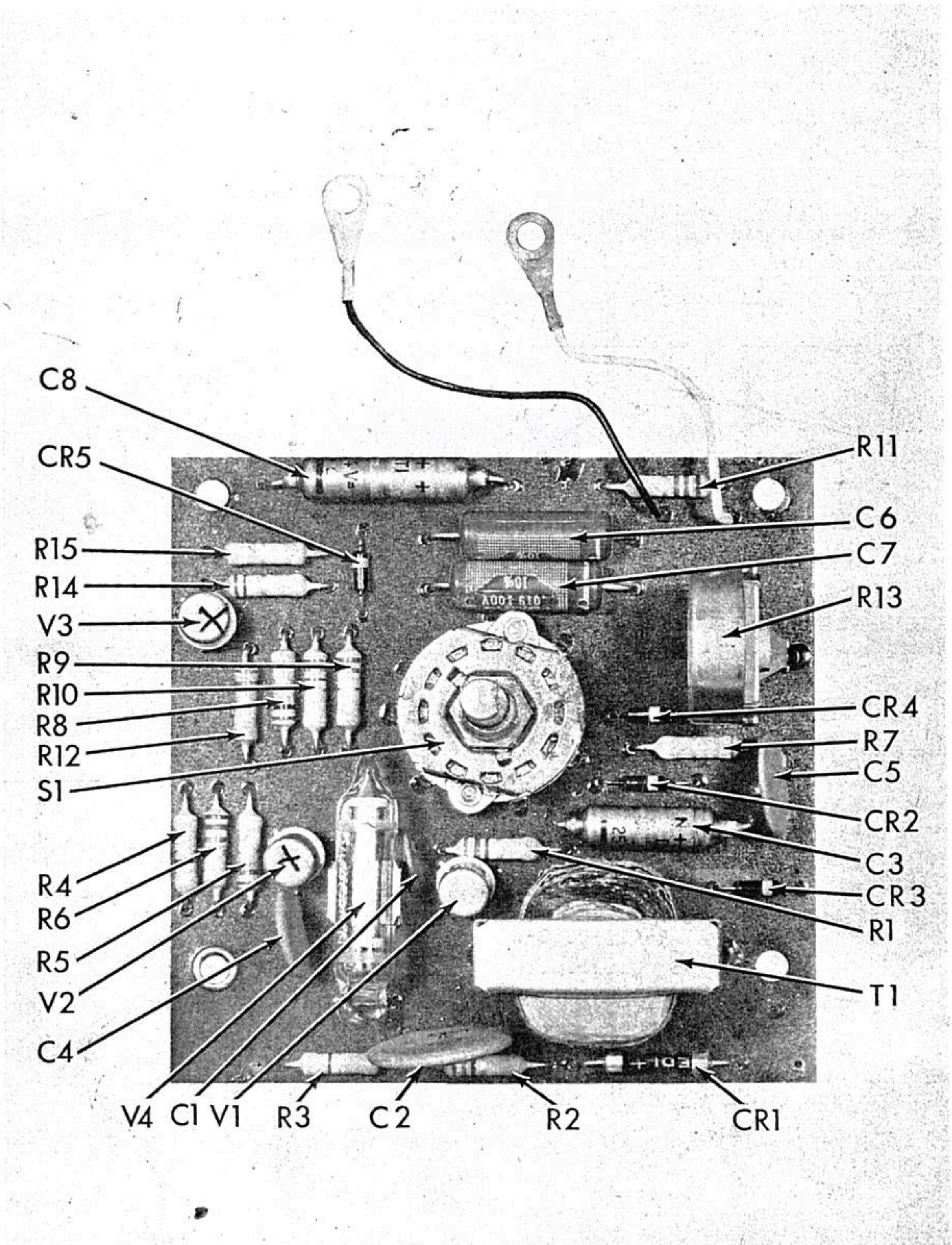


Figure 5-6. Location of Components

PARTS LIST

Electrical Components

Circuit Symbol	Description	Function	Manufacturer & Part No.	Lionel Part No.
B	Batteries "D" size 1-1/2V NEDA 13	Power supply	National Carbon 950	T1-19
C1	Capacitor 0.0025 uf +80% -20% 50V	Power supply feedback capacitor	Centralab Division Globe Union	T3-536
C2	Capacitor 0.01 uf +80% -20% 1.4KV	High voltage filter	Centralab Division Globe Union	T3-534
C3	Capacitor 25uf 25V	Low voltage filter	United Mineral	T3-3
C4	Capacitor 0.0025 uf +80% -20% 1.4KV	Signal coupling and D.C. blocking	Centralab Division Globe Union	T3-535
C5	Capacitor 0.05 uf +80% -20% 50V	Audio coupling and differentiating	Central Division Globe Union	T3-537
C6	Capacitor Mylar 0.002 uf 100V	Timing X100 range	Good-All Electric Mfg.Co. Type 630	T3-532
C7	Capacitor Mylar 0.019 uf 100V	Timing X10 and X1 range	Good-All Electric Mfg. Co. Type 630	T3-533
C8	Capacitor 200uf 3V	Current integrating	United Mineral	T3-500

Circuit Symbol	Description	Function	Manufacturer & Part No.	Lionel Part No.
CR1	Rectifier	H.V. rectifier	Electronic Devices, Inc.	T8-108
CR2	Rectifier silicon	L.V. rectifier	Lionel Electronic Labs. T8-127	T8-127
CR3	Rectifier silicon	Audio clipping	Lionel Electronic Labs. T8-127	T8-127
CR4	Rectifier silicon	Audio coupling	Lionel Electronic Labs. T8-127	T8-127
CR5	Rectifier silicon	Meter rectifier	Lionel Electronic Labs. T8-127	T8-127
GM	Geiger tube	Detector	Lionel Electronic Labs. 6993	6993
H	Headphone	Aural indicator	Lionel Electronic Labs. T12-21	T12-21
J1	Phone jack	Headphone connector	Lionel Electronic Labs. T11-967	T11-967
M	Meter 0-50 ua	Indicator	Lionel Electronic Labs. T6-85	T6-85
R1	Resistor 820 ohm 1/2W 10%	V1 base bias	United Mineral	T10-235
R2	Resistor 1.8 megohm 1/2W 10%	VR tube load resistor	United Mineral	T10-275

Circuit Symbol	Description	Function	Manufacturer & Part No.	Lionel Part No.
R3	Resistor 3.3 megohm 1/2W 10%	GM tube load resistor	United Mineral	T10-278
R4	Resistor 3.3K ohm 1/2W 10%	Bias divider for V2	United Mineral	T10-242
R5	Resistor 22K ohm 1/2W 10%	V2 base resistor	United Mineral	T10-252
R6	Resistor 1.2K ohm 1/2W 10%	Bias divider for V2	United Mineral	T10-237
R7	Resistor 27K ohm 1/2W 10%	Rectifier CR4 reference resistor	United Mineral	T10-253
R8	Resistor 10K ohm 1/2W 10%	V2 collector load	United Mineral	T10-248
R9	Resistor 18K ohm 1/2W 5%	Current limiting X100 and X10 ranges	United Mineral	T10-118
R10	Resistor 1.8K ohm 1/2W 5%	Current limiting X1 range	United Mineral	T10-94
R11	Resistor 8.2K ohm 1/2W 10%	Meter time constant	United Mineral	T10-247
R12	Resistor 18K ohm 1/2W 10%	Multivibrator cross coupling	United Mineral	T10-251
R13	Potentiometer 25K ohm ±30%	Calibration control	Chicago Telephone Supply Corp.	T10-1504

Circuit Symbol	Description	Function	Manufacturer & Part No.	Lionel Part No.
R14	Resistor 150K ohm 1/2W 10%	V3 base resistor	United Mineral	T10-262
R15	Resistor 39K ohm 1/2W 10%	V3 collector load	United Mineral	T10-255
S1	Switch	Range selection	Chicago Telephone Supply Corp.	T13-206
T1	Transformer	Blocking osc. power supply	Lionel Electronic Labs. T14-185	T14-185
V1	Transistor PNP	Power supply	Lionel Electronic Labs. T8-124	T8-124
V2	Transistor PNP	Multivibrator	Lionel Electronic Labs. T8-125	T8-125
V3	Transistor PNP	Multivibrator	Lionel Electronic Labs. T8 126	T8-126
V4	Voltage regulator tube	Regulates high voltage	Lionel Electronic Labs. 416	416

21164
21167

Mechanical Components

Description	Function	Manufacturer & Part No.	Lionel Part No.
Battery holder assembly	Holds batteries	Lionel Electronic Labs. T32-2	T32-2
Battery retainer clip	Holds batteries	Lionel Electronic Labs. T28-62	T28-62
Cap and chain assembly	Phone jack cover	Lionel Electronic Labs. T32-5	T32-5
Case bottom	Bottom of instrument	Lionel Electronic Labs. T32-4	T32-4
Gland	Water seal	Lionel Electronic Labs. T20-968	T20-968
Handle assembly	Holds probe	Lionel Electronic Labs. T32-3	T32-3
Handle gasket	Water seal	Lionel Electronic Labs. T20-992	T20-992
Jack gasket	Water seal	Lionel Electronic Labs. T20-962	T20-962
Knob	Range switch knob	Lionel Electronic Labs. T11-512	T11-512
Meter gasket	Water seal	Lionel Electronic Labs. T20-1011	T20-1011

Description	Function	Manufacturer & Part No.	Lionel Part No.
Panel	Top of instrument	Lionel Electronic Labs. T28-60	T28-60
Panel gasket	Water seal	Lionel Electronic Labs. T21-46	T21-46
Printed Circuit Board	Supports components	Lionel Electronic Labs. T11-529	T11-529
Probe-cable assembly	Holds geiger tube	Lionel Electronic Labs. T32-1	T32-1
Strap Assembly	Carrying strap	Lionel Electronic Labs. T20-989	T20-989